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ABSTRACT

This paper provides guidelines for the audiologic assessment of infants and young children, highlighting recent technologic advances in auditory electrophysiology, acoustic immitance measure procedures, and behavioral audiometric techniques. First, audiologic assessment guidelines developed by the American Speech-Language-Hearing Association are discussed and the specific protocol used at the Rose F. Kennedy Center, Albert Einstein College of Medicine (New York) is outlined. Components of this protocol are then discussed in further detail, including: (1) auditory brainstem response (ABR) evaluation, (2) the use of acoustic immitance measures, (3) behavioral audiologic assessment, (4) visual reinforcement audiometry (VRA), (5) optimizing the clinical VRA procedure, (6) obtaining ear-specific thresholds, and (7) developing recommendations for amplification. Contains 40 references. (DB)

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Chapter 10

AUDIOLOGIC ASSESSMENT OF INFANTS AND TODDLERS

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The assessment of hearing in infants and young children remains one of the most clinically challenging tasks of audiologic practice. Current auditory electrophysiologic procedures, as well as otoacoustic emissions, acoustic immittance measurements, computer-assisted behavioral test procedures, and electroacoustic (real-ear) assessment techniques have gained rapid popularity for use in the evaluation and follow-up of infants, toddlers, and difficult-to-test children. While these newer procedures have facilitated the technical assessment process per se, the role of the pediatric audiologist has not diminished in importance; rather, it has become more critical.

The demands on today's clinician are multiple. The pediatric audiologist must (a) acquire and compile meaningful background information, (b) select the test procedures most appropriate for an individual child, (c) administer (or at least supervise) all assessment procedures, (d) examine the concordance among test outcomes, (e) determine the reliability of the results, (f) assess the validity of the clinical findings, and finally, (g) interpret and convey the outcome to parents and professionals involved in the child's present and future care.

Guidelines for Audiologic Assessment

Unfortunately, while our professional preparation provides academic and practical training in adult audiologic assessment, in general, audiologists receive little specific coursework and a paucity of practicum experience in pediatric audiology (Oyler & Matkin, 1987). Moreover, unless employed by a facility specifically servicing young children, many audiologists assess hearing in infants and toddlers only occasionally rather than in daily practice. With infrequent contacts, there is little chance to gain clinical expertise with the population.

The need for a comprehensive document designed to provide direction and support for clinicians involved in the audiologic assessment of infants and toddlers has been recognized. Recently, the ASHA Committee on Infant Hearing developed the "Guidelines for the Audiologic Assessment of Children from Birth Through 36 Months of Age" (ASHA, 1991) to serve as the basis for a pediatric assessment strategy. The document provides the rationale, the background, the justification, and the ethical, practical, and legislative mandates for such guidelines.

The Guidelines strongly support the use of the test battery approach (Jerger & Hayes, 1976) in the assessment of infants and young children, specifying the auditory brainstem response (ABR), acoustic immittance measurements, and behavioral test procedures as the essential components of the pediatric test armamentarium. In addition, the Guidelines stress (a) the need for timely, accurate, and comprehensive hearing evaluations of infants and young children, (b) the selection of tests and interpretation of data appropriate for the child's developmental age, (c) the need for frequency-specific and ear-specific assessments of auditory function, and, (d) the importance of evaluating speech recognition ability.

Although three assessment procedures compose the assessment battery, only two are recommended for routine use: a behavioral hearing assessment and acoustic immittance measurements. The Guidelines suggest that while the ABR is an extremely useful technique, it is not always necessary in the assessment of every young child when a reliable, frequency-specific behavioral audiologic evaluation can be completed. Moreover, the Guidelines point out that the conventional click-ABR does not meet the requirement of a "frequency-specific" measure and recommend the addition of a 500-Hz tone to assess low-frequency sensitivity.

There are cases for which the ABR would be considered the test of choice for estimating threshold, for example, in infants 4 months of age and younger and in children with severe developmental deficits. Regardless of the ABR outcome, or the age/developmental level of the young child, however, the Guidelines stress that a behavioral assessment of auditory function should be completed routinely.

Whenever possible (usually beginning at about 5 to 6 months of age), operant conditioning procedures are recommended (visual reinforcement audiometry (VRA), or conditioned play audiometry) for frequency-specific

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threshold evaluation. When conditioning procedures are inappropriate or unreliable, the Guidelines recommend that the clinician observe the child's auditory behaviors directly and solicit the parents report of their child's hearing ability. The use of traditional behavioral observation audiometry (**BOA**) (Northern & Downs, 1984) as the sole method of determining threshold sensitivity in very young infants or highly-compromised children is discouraged.

In addition to tests of sensitivity, acoustic immittance procedures (tympanometry and acoustic reflex assessment) are viewed as an integral component of the pediatric test battery. The Guidelines state that while optimum test parameters for acoustic immittance assessment in infants (e.g., probe frequency for tympanometry) remain controversial (Margolis & Shanks, 1990), the routine use of acoustic immittance procedures is recommended during each audiologic visit, irrespective of the age of the child and prior to interpreting behavioral and electrophysiologic estimates of hearing sensitivity. The need to obtain bone conduction thresholds (with behavioral and electrophysiologic procedures) is also suggested, in order that the type of hearing loss can be delineated and the cochlear reserve estimated.

Finally, the Guidelines stress that an assessment is not complete until caregivers and other professionals involved in the case have been informed of the results and habilitation and/or medical plans have been formalized.

At our clinical research facility at the Rose F. Kennedy Center, Albert Einstein College of Medicine, we have developed a test protocol for use in our routine assessment of hearing in infants and young children. Several factors related to the choice and incorporation of test procedures were considered, including (a) the suitability of the procedure to our site, (b) the time/cost versus benefit of the measures, and, (c) the demonstrated reliability and validity of the procedures.

Table 1 presents our standard protocol for infants and toddlers (based on Gravel & Stapells, 1990). Our facility serves a neuro-developmentally at-risk pediatric population; therefore, the protocol is divided according to chronologic/developmental ages, similar to the categories adopted in the recent **ASHA** Guidelines. Frequently, a child's developmental level has been determined by formal methods prior to audiologic assessment (Wallace, 1989). Lacking such information, in the case of infants born prematurely, we routinely employ the "corrected age" of the baby when selecting and interpreting test outcomes.

The discussion that follows describes the measures listed in Table 1. These procedures meet our previously mentioned inclusion criteria and are in good agreement with those recommended in the **ASHA** Guidelines. Although other measures, such as cortical auditory evoked potentials (Kurtzberg, 1989) or otoacoustic emissions (Abdo, Feghali, & Stapells, submitted) may also be used for auditory system evaluation, the "core" of our audiologic assessment is composed of the procedures discussed below.

ABR Evaluation

The specific protocols for the electrophysiologic, frequency-specific assessment of air-and bone-conduction thresholds in infants and toddlers are presented in their entirety in Stapells (1989). Briefly, Stapells suggests that the high-intensity click-**ABR** be used for the assessment of the integrity of the auditory pathways to the level of the brainstem (i.e., a neurologic assessment). Moreover, he recommends that auditory sensitivity not be estimated from conventional click-**ABR** thresholds, but determined using frequency-specific (tonal) stimuli. Specifically, a "tones in notched noise" technique is recommended (Stapells, Picton, Perez-Abalo, Read, & Smith, 1985) minimally including 500 **Hz** and 2000 **Hz**, and additionally, when possible,

TABLE 1. Preferred pediatric protocol for assessing auditory sensitivity.

For neonates and infants (birth to 3 months chronologic/developmental age):
1. Immittance: Tympanogram and ipsilateral acoustic reflexes (660 Hz)
2. Frequency-specific **ABR** (**ABR^{FS}**): minimally, air-conducted 2000-Hz tones in each ear (normal: 20–30 dB nHL)
3. Neurologic **ABR**: High-intensity clicks (I & V)
4. If **ABR^{FS}** is abnormal, knowledge of middle ear and neurologic status essential
   a. Bone-conducted **ABR^{FS}**
   b. Observe behavioral responses to sound (air and bone-conducted)

For older infants (4 or 5 months–12 months):
1. Visual Reinforcement Audiometry: Frequency-specific stimuli, preferably ear-specific. (Secondarily, responses to speech stimuli): Air-conducted.
2. Immittance: Tympanogram and acoustic reflexes (660/220 Hz).
3. If above abnormal: Bone-conducted behavioral testing.
4. **ABR^{FS}** if unable to obtain reliable behavioral responding to frequency-specific stimuli using an operant conditioning procedure after maximum of 2 visits: **ABR** protocol same as for younger ages.

For toddlers (13 months–30 months):
1. Visual Reinforcement Audiometry (or variant): Frequency-specific stimuli, preferably ear-specific. Air-conducted. (Secondarily, assess speech detection and speech recognition; informally or formally.)
2. Immittance: Tympanogram and acoustic reflexes (220 Hz).
3. If abnormal: Bone-conducted behavioral testing.
4. **ABR^{FS}** if unable to demonstrate reliable behavioral responding to frequency-specific stimuli using an operant conditioning procedure after 2 visits: **ABR** protocol same as younger ages.

Note: Based on Gravel and Stapells (1990).

4000 Hz (Stapells, 1989). This tone-ABR procedure is highly correlated with the pure-tone audiogram in persons with normal hearing and listeners with hearing impairment (Stapells, Picton, Durieux-Smith, Edwards, & Moran, 1990). Other frequency-specific techniques have also been demonstrated to provide reliable audiometric information (e.g., Gorga, Kaminski, Beauchaine, & Jesteadt, 1988).

Although the air-conducted frequency-specific ABR is very useful, it is not sufficient, particularly in pediatric practice. The bone-conducted ABR has now become a routine part of our audiologic assessment armamentarium (Stapells, 1989; Stapells & Ruben, 1989). It has proven to be extremely useful clinically, providing information on both the type of hearing loss, the degree of sensorineural involvement, and in the case of bilateral conductive deficits, a cochlea-specific response (Gravel, Kurtzberg, Stapells, Vaughan, & Wallace, 1989; Stapells, 1989; Stapells & Ruben, 1990; Yang, Rupert, & Moushegian, 1987).

When administered and interpreted appropriately, the frequency-specific and the air- and bone-conducted ABR provide an accurate estimate of auditory sensitivity in the vast majority of our pediatric clinical cases. However, we have found that in some cases of infants with otitis media, the air-conducted ABR significantly overestimates the actual degree of hearing loss caused by the transient middle ear pathology (Gravel et al., 1989; Stapells, 1989; Stapells & Gravel, 1990). While infrequent in occurrence, this finding is clinically relevant, particularly when infants are assessed using ABR alone and without benefit of acoustic immittance assessment and/or pneumo-otoscopic inspection. The ABR threshold elevation seen in some cases of otitis media is greater than that normally considered consistent with conductive disorder alone. Thus, without information to the contrary (such as behavioral thresholds or bone-conducted responses), the clinician could conclude that the hearing loss found on ABR assessment was mixed or sensorineural in type (Gravel et al., 1989; Stapells, 1989; Stapells & Gravel, 1990).

At our facility, an ABR is never completed without some behavioral assessment of auditory function, although the reverse is not always true. The utility of the ABR as a measure of auditory sensitivity is directly related to an infant's or young child's ability to provide reliable behavioral responses to tonal stimuli. Moreover, it is unwise to view the ABR (particularly the conventional click-ABR) as a test of "hearing" in its most global sense. Clinicians frequently may disregard this fact in their haste to accept as valid only "objective" electrophysiologic findings. However, once a clinician has inappropriately diagnosed a case based on a traditional click-ABR alone, the experience is usually sufficiently sobering for the practitioner to arrive at the same conclusion regarding hearing and the ABR (see Gravel et al., 1989; Stapells, 1989).

Acoustic Immittance Measures

Our acoustic immittance procedures presently incorporate the reports of Marchant, McMillan, Shurin, Johnson, Turczyk, Feinstein, and Panek (1986), as well as those of Holte, Margolis, and Cavanaugh (1991). Specifically, at our facility, admittance tympanograms are obtained from infants under 6 months of age using a 660-Hz probe frequency (Marchant et al., 1986), in addition to the conventional 220-Hz probe stimulus (Holte et al., 1991). A flat (noncompliant or Jerger Type B) tympanogram (in the presence of an unoccluded ear canal) is considered evidence of conductive pathology (otitis media). In our very young babies, should the 220-Hz and 660-Hz tympanograms differ, we presently give greater weight to that obtained using the 660-Hz probe frequency in determining the presence or absence of middle ear dysfunction (Marchant et al., 1986). When the baby's state makes it apparent that only one tympanogram will be obtained, the 660-Hz probe is the frequency of choice. Within this same young infant age group, the presence of ipsilateral acoustic reflexes is examined using a 660-Hz probe frequency only (Marchant et al., 1986).

When an infant or young child is being assessed with both ABR and behavioral audiometry, frequently a "quick" screening tympanogram (220-Hz probe) is obtained prior to the behavioral assessment. We then reserve the more complete acoustic immittance assessment (two-frequency tympanograms and ipsilateral acoustic reflex assessment) until the child is asleep and quiet for ABR assessment.

Behavioral Audiologic Assessment

As previously suggested, there is a tendency among audiologists today to minimize the importance of behavioral assessment in pediatric audiologic practice, or when electrophysiologic procedures are available, to abandon behavioral testing entirely. These circumstances have arisen for several likely reasons. First, the clinician may lack confidence in his or her ability to reliably assess hearing in infants by "subjective" methods. Secondly, the audiologist's past training and experiences may have suggested that infants are incapable of providing "threshold" responses.

Indeed, when appropriate psychometric procedures are used, both observational (Olsho, Koch, Halpin, & Carter, 1987) and conditioning (Wilson & Thompson, 1984) procedures become powerful tools that can be incorporated into routine clinical use. Behavioral methods presently available allow us to reliably delineate normal hearing function, and to assess and monitor the type, degree and configuration of any existing peripheral hearing loss (Bernstein & Gravel, 1990; Diefendorf, 1988; Gravel, 1989). Moreover, suprathreshold procedures allow the evaluation of speech discrimination ability (Eilers, Wilson, & Moore, 1977), frequency (Olsho, 1984) and intensity (Sinnott & Aslin, 1985) discrimination, and higher-order binaural auditory abilities such as speech-in-noise discrimination (Nozza, Rossman, Bond, & Miller, 1990) and release from masking (Nozza, Wagner, & Crandell, 1988).

Of critical importance is the fact that behavioral audiometric test procedures are efficient, safe, and cost-effective. As clinicians, we must consider the reasons we are willing to spend time, effort, and considerable financial investment in electrophysiologic, acoustic immittance, and real-ear measurement equipment, and yet hesitate to de-

vote similar clinical resources toward the improvement of our behavioral procedures, facilities, and equipment.

Visual Reinforcement Audiometry

The behavioral assessment techniques used for infants and young children at our facility are versions of the operant head-turn procedure. Clinically, the audiometric test procedure is known as visual reinforcement audiometry (**VRA**). It is important to realize that **VRA** is not a generic term that can be used to refer to any test technique that employs visual reinforcement. The term **VRA** should be used to designate a specific audiometric test procedure such as described by Wilson and Thompson (1984).

VRA is not a localization procedure. When the infant is rewarded for making a "correct" localization (in the direction of one loudspeaker versus another), the correct term is conditioned orienting response (**COR**) audiometry. The confusion in terminology appears to arise from the motor response itself, that is, the head turn. Because the same movement is also made when an infant searches for the source of a sound, clinicians tend to equate the two events.

The head turn, however, is merely a motor response appropriate for infants. The act itself is similar to a block-drop during play audiometry, or a hand-raise or button-push during conventional audiometric assessment. The head turn is only the method by which the infant indicates that a sound has been detected.

In the **VRA** procedure the head turn is brought under stimulus control (operantly conditioned). During the shaping or training phase, the **VRA** procedure may capitalize on the infant's natural tendency to search for the source of a novel sound. The infant usually turns spontaneously, looking in the direction of the loudspeaker upon the initial presentation of a suprathreshold stimulus (Thompson & Folsom, 1984). Usually the loudspeaker is located directly (approximately 90°) to one side of the baby. Placing the visual reinforcement display close to the loudspeaker allows the clinician to easily "reward" that initial localization response.

However, the spontaneous localization is not necessary to the success of the **VRA** procedure. Although in normal-hearing infants an initial response usually occurs at low levels (30 dB HL; Thompson & Folsom, 1984), in some cases (as with infants with profound or unilateral hearing loss), a directional response may not occur. If the spontaneous response does not occur after increasing the intensity of the signal, then the clinician must teach the infant the correct response. In addition, the clinician may choose to change the stimulus presentation mode to facilitate shaping such as changing from a soundfield stimulus presentation to a low-frequency bone-conducted signal, or presenting a high-level signal through an earphone (or insert) receiver.

Repeated pairings of an audible (or vibrotactile) stimulus with the activation and illumination of the reinforcement teaches the infant to associate the presence of the stimulus with the availability of visual reinforcement. Shaping is complete when the infant detects the stimulus and turns in anticipation of the reinforcement. Concomitantly, the infant must be taught not to respond when no stimulus is present. For a reliable **VRA** assessment, both conditions are equally important (Bernstein & Gravel, 1990).

Once the association is learned, regardless of the mode of stimulus presentation (soundfield speaker, earphone, bone oscillator), the response contingencies remain the same (stimulus, response, reward; no stimulus, response, no reward) as does the response itself (a uni-directional head turn towards the reinforcement display). When a change is made to a different transducer (i.e., earphone, bone oscillator), usually all that is required is that the infant is reacquainted with the "correct" response.

Clinicians frequently ask if this means that our facility has only one visual reinforcement display. A single display unit (housing three separate toys) located in one corner of the test suite is utilized exclusively for both our clinical and computer-controlled **VRA** procedures. However, a second visual reinforcement unit (located in an adjacent corner) is available for use in a forced-choice discrimination paradigm (Bernstein, 1989). During **VRA** procedures, the second display unit is hidden from the infant's view. Such an arrangement (two displays, one out of view) could allow the clinician interested in maintaining the availability of two reinforcement units for **COR** audiometry to do so. It is recommended, however, that thresholds be obtained with **VRA** prior to exploring localization abilities. (See Gravel, 1989, for a complete description of the facilities, test suite arrangement, and the modifications incorporated.)

Optimizing the Clinical VRA *Procedure*

Whether the clinician is using a manual test technique or a **VRA** procedure assisted by a logic system or computer, the following factors should be considered when attempting to optimize audiometric information: (a) reducing bias, (b) increasing attention and motivation, and, (c) decreasing the false-alarm rate. (See Eilers, Miskiel, Ozdamar, Urbano, & Widen, 1991, for an excellent discussion of other factors that increase the efficiency and accuracy of the **VRA** procedure.)

Reducing bias. The most important way to reduce observer bias is with the inclusion of catch trials (non-signal, control trials) into the **VRA** procedure. Regardless of whether the assessment is accomplished manually or is assisted by a logic system or computer, catch trials are critical. When the **VRA** procedure is computer-assisted, catch trials can be programmed to occur randomly during the threshold search with whatever frequency the clinician feels appropriate (Bernstein & Gravel, 1990; Eilers et al., 1991).

When using either a single-examiner or two-examiner manual **VRA** procedure, a recording form that provides for both signal and catch trials is appropriate. The use of a simple recording form serves to maintain a response record and provides a schedule for the examiner to deliver control trials randomly throughout the threshold search. An example of such a form is presented as an Appendix.

Examination of the infant's responses during catch trials helps to determine the degree of confidence that can be

placed in the behavioral result. A high false-alarm rate (usually greater than 25%) indicates that the infant was not under stimulus control; that is, the infant had not learned the response contingencies and was essentially randomly turning towards the reinforcers during the threshold search. In this case, the audiologist can have little confidence that the obtained threshold reflects true hearing sensitivity (Bernstein & Gravel, 1990; Eilers et al., 1991).

When computer-assisted, **VRA** can be bias-free even when a single examiner is used, as in the **ISP** (Interweaving Staircase Procedure, Bernstein & Gravel, 1990) and **IVRA** (Intelligent **VRA**, Intelligent Hearing Systems, Inc.) procedures. The computer controls the trial type and delivers a signal that marks the onset and duration of a trial and masks the examiner as to trial type. Through a foot-switched interface with the computer, the examiner indicates when a head-turn response occurs during a trial. The computer delivers reinforcement only when a response is made during a signal trial.

The use of catch trials to reduce bias is also critical during manual **VRA**. Using two audiologists to assess infants can be justified only when the examiner responsible for distracting the infant (located inside the test suite) is unaware of whether a signal or control trial is being presented. This can be easily accomplished by having the test-examiner mark the onset and duration of every trial (both signal and catch) with white noise (presented through headphones). This trial marker should be sufficiently loud to mask test signals presented to the infant. The delivery of reinforcement is made only when the infant responds appropriately during a signal trial, determined from the vote of the unbiased examiner. Unless the examiner in the booth with the infant is "deafened" as to trial type, two-person testing has the same degree of bias as a single-examiner manual **VRA** procedure.

The possible bias introduced by the parent holding the infant during testing must also be considered. Ideally, the parent wears earphones through which masking (taped music) is delivered. Thus the parent cannot provide any cue to the infant. Some clinicians, however, are reluctant to mask the parent during audiologic assessment, feeling that the parent should have knowledge of both the level and frequency of the sounds to which the infant is, or is not, responding. This awareness they feel, facilitates the counseling process.

Increasing attention and motivation. Sufficient audiologic data can be obtained with **VRA** only when the infant continues to respond over repeated trials. Ideally, if air-conducted thresholds can be obtained at 500, 2000, and 4000 Hz in each ear and unmasked bone-conduction thresholds assessed at the same frequencies, the audiologist would have ample information on which to base follow-up strategies. Thus, it is critical that the infant's attention and motivation are high throughout the test session.

Several methods have been suggested to optimize and monitor attention and motivation during **VRA** assessment. First, increasing the novelty of the reinforcement serves to maintain the attention of the infant (Trehub & Schneider, 1984; Wilson & Thompson, 1984). This can be accomplished by using several animated and illuminated toy reinforcers that are out of view (behind dark smoked Plexiglas) except during periods of reinforcement (see Gravel, 1989, for an example of such a visual display unit).

Other ways to increase attention include shortening the reinforcement period (Culpepper, 1990a), changing the response task (during play audiometry, Thompson, Thompson, & Vethivelu, 1989), or changing the stimulus (as from warble tone to narrow band noise, Culpepper, 1990b). Primus (1988) suggests that signaling the approach of a trial (as in telling the child to listen) increases attention to the task. Finally, a break in the session, during which the toy reinforcers are changed, has frequently proven to be beneficial at our facility.

Bernstein and Gravel (1990) have suggested monitoring the infant's attention and motivation during a computerized **VRA** procedure by the inclusion of high-level probe trials during the threshold search. Examining the infant's rate of response to the probe trials during the test session allows the audiologist to determine whether the child was equally attentive at the beginning, middle, and end of the threshold search.

Decreasing the false alarm rate. As discussed previously, a high false alarm rate is a problem during **VRA** assessment. When we obtain a high rate of false alarms during a threshold search, we first attempt to retrain the infant on the response contingencies. Increasing the number of unrewarded catch trials during the reshaping phase, as well as increasing the novelty of the toy used to keep the infant's attention at the midline position, may be beneficial.

Indeed, it could be the case that the false alarm rate is high because the stimulus used to condition the child was not audible. That is, the infant never learned the response contingency because he or she was never aware of the stimulus. This possibility, of course, is always of concern to the pediatric audiologist who frequently examines young children with hearing loss. As suggested previously, determining whether the infant provides reliable responses when a low-frequency bone-conducted (vibrotactile) signal or a higher-intensity air-conducted signal is presented can provide valuable information as to the reason behind a high false alarm rate.

Obtaining Ear-Specific Thresholds

Ear-specific responses can be accomplished using behavioral test procedures. It appears that clinicians have a misconception regarding their ability to obtain ear-specific thresholds from young infants. In a recent review of our clinical and research records (Gravel & Traquina, in press), over 80% of infants between 6 months and 24 months of age provided ear-specific thresholds using conventional earphone presentation (TDH-49 earphones, MX-41/AR cushions with padded infant headband). Generally, preparing the parent, readying the reinforcers, and persistence are rewarded. It is important to note that the age group with which we were least successful in obtaining ear-specific responses was the 20- to 24-month-olds. Not surprisingly, it is less of a problem to obtain ear-specific responses from infants than from toddlers.

TABLE 2. Test results required before fitting amplification (under 4 months).

For NICU infant:
1. Outcome of ABR air and bone conduction. Reliable results at least two test visits, one after the age of 3 months CA in the absence of middle ear involvement
2. Consistent findings by behavioral assessment (for air and bone conduction)
3. Consistent immittance (tympanometry and acoustic reflex)/otoscopy findings
4. In process of clearance by ENT (includes CT, bloods, ENG with fistula tests, opthalmologic exam)
5. Provisions for habilitation/follow-up program/plan

For infant with bilateral atresia (cranio-facial):
1. Outcome of ABR[FS] air and bone conduction at earliest exam
2. Provisions for habilitation/follow-up program

For healthy, full-term neonate with familial history of hearing loss:
1. Outcome of ABR[FS] air and bone conduction. Reliable results at two test visits in the absence of middle ear involvement
2. Consistent findings by behavioral assessment (air and bone conduction)
3. Consistent immittance (tympanometry and acoustic reflex)/otoscopy findings
4. In process of clearance by ENT (includes CT, bloods, ENG with fistula tests, opthalmologic exam)
5. Provisions for habilitation/follow-up program/plan.

Note. Based on Gravel and Stapells (1990).

More recently, we have had similar if not somewhat better results using insert receivers (EAR-3A) with pediatric eartips. However, in our experience infants and toddlers who vehemently refuse earphones generally treat insert receivers with the same degree of respect.

Recommendations for Amplification

Frequently, we are asked when it is appropriate to fit amplification to infants, that is, how soon we feel comfortable fitting hearing aids and what criteria are used to make that decision. Table 2 presents the information required before fitting amplification to infants under 4 months of age (based on Gravel & Stapells, 1990). These recommendations are based on our experience with a high-risk population, the majority of whom had highly compromised courses in the neonatal intensive care unit (NICU) resulting from very low birthweight (<1500 grams), severe perinatal asphyxia, and/or who required prolonged mechanical ventilation. Note that our criteria differ for NICU infants than for infants born with a specific craniofacial malformation (bilateral atresia), or for healthy fullterm babies suspected of having familial, congenital hearing loss.

We feel this somewhat conservative approach to amplification recommendation is justified with a high-risk population. While the early identification of hearing loss is critical, it is equally true that a thorough and accurate assessment of hearing (as we have previously defined it) is imperative before parents are counseled and habilitation is initiated. We find this entire process to be more of a problem in an NICU population, as well as in infants who experience a high incidence of middle ear involvement. Often our initial findings are modified in the early months of life (postterm and following discharge from the NICU). For example, the stability of the ABR is best at about 3 months to 4 months corrected age (Stapells, 1989; Durieux-Smith, Picton, Edwards, MacMurray, & Goodman, 1987). Thus, we do not advocate the diagnosis of hearing loss or fitting of amplification during the NICU period. The goal of completing a thorough audiologic assessment, amplification selection, evaluation, and the initiation of an early intervention program (Joint Committee on Infant Hearing, 1991) can still be accomplished in a timely manner.

In summary, the audiologic assessment of infants and toddlers has been facilitated for the pediatric audiologist by recent technologic advances in auditory electrophysiology, acoustic immittance measure procedures, and behavioral audiometric techniques. Although progress has been significant, it is still the careful, thoughtful, highly trained, and knowledgeable clinician who must incorporate the procedures into a comprehensive audiologic assessment.

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APPENDIX

Sample test form for use during VRA assessment:

Name: _____ **Date:** _____

Age: _____ **Examiner:** _____

Test Frequency: _____ **Hz** **Threshold:** _____ **dB HL**

Start Level: _____ **dB HL** **Step Size:** _____ **dB**

FA#/C# = _____ **%**

Level	*Response*	*Level*	*Response*	*Level*	*Response*	*Level*	*Response*
___	1. S___	___	11. C___	___	21. C___	___	31. S___
___	2. S___	___	12. C___	___	22. S___	___	32. C___
___	3. S___	___	13. S___	___	23. S___	___	33. S___
___	4. C___	___	14. S___	___	24. C___	___	34. S___
___	5. S___	___	15. S___	___	25. S___	___	35. S___
___	6. C___	___	16. S___	___	26. S___	___	36. S___
___	7. S___	___	17. C___	___	27. C___	___	37. S___
___	8. S___	___	18. S___	___	28. S___	___	38. C___
___	9. S___	___	19. S___	___	29. S___	___	39. S___
___	10. S___	___	20. S___	___	30. S___	___	40. S___

Key: + = Hit − = Miss FA = False Alarm CR = Correct Rejection

Comments:

(75% signal trials; 25% catch trials w/o signal.)